Nucleosynthetic neodymium isotope anomalies of bulk chondrites.

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Introduction: A variety of isotope anomalies have been discovered in bulk chondrites and differentiated meteorites (e.g., Cr, Sr [1–2]). These results point to the existence of planetary-scale isotope heterogeneities for refractory heavy elements. By contrast, some elements exhibit uniform isotope compositions across different meteorite groups (e.g., Te, Os [3–4]). Such inconsistencies regarding the isotope distribution are critical to understanding the processes occurred in the solar nebula and/or in planetary bodies.

A previous work on high precision Nd isotope analyses for meteorites found that chondrites possessed $^{142}Nd/^{144}Nd$ ratios ~20 ppm lower than those in terrestrial rocks [5]. The anomaly was interpreted to be caused by the Sm-Nd fractionation via early differentiation of the terrestrial mantle. Subsequent studies reported variations in $^{142}Nd/^{144}Nd$ ratios among enstatite, ordinary and carbonaceous chondrites [6]. Because these variations roughly correlated with the isotope anomalies of stable Nd isotopes (e.g., $^{148,150}Nd/^{144}Nd$), the $^{142}Nd/^{144}Nd$ variations are considered to be induced by the nucleosynthetic anomalies in the early Solar System. On the other hand, the isotopic composition of terrestrial materials seems to deviate from the correlation among three types of chondrites.

The existence of Nd isotope anomalies in bulk aliquots of chondrites remains unclear unless high precision Nd isotope data with complete sample digestion become available. In this study, we revisit high precision Nd isotope analysis of chondrites coupled with a new sample digestion technique that confirms complete dissolution of acid resistant presolar grains. We also develop a modified dynamic multicollection method using TIMS to improve the analytical reproducibilities for Nd isotope ratios.

Experimental: We investigated five carbonaceous chondrites (Y980115 CI; Tagish Lake, C2-ung; Dhofar 1432, CR2; Allende, CV3; Dar al Gani 190/082, CO3), seven ordinary chondrites (Kesen, H4; Forest city, H5; Etter, H6; Saratov, L4; Modoc (1905), L6; Hamlet, LL4; Tuxtuac, LL5; St. Séverin, LL6) and one enstatite chondrite (Y980223, EH6). The ordinary chondrites and enstatite chondrite were dissolved by a conventional acid digestion method using HNO_3 + HF + $HClO_4$ [7]. For carbonaceous chondrites, each sample was digested using a high-pressure digestion system (DAB-2, Berghof) with HF + HNO_3 + H_2SO_4 to completely dissolve acid resistant presolar grains [2]. The Nd isotope compositions were measured by TIMS (Triton-*plus*, Tokyo Tech). In this study, we developed a modified "dynamic" method in which $^{142,148,150}Nd/^{144}Nd$ ratios were obtained with a 2-line cup configuration.

Results and Discussion: Fig. 1 shows the $\mu^{142}Nd$–$\mu^{148}Nd$ plots for a part of meteorite samples analyzed in this study. The line with a negative slope in Fig. 1 represents the mixing line between the terrestrial composition and the putative *s*-process endmember calculated from [8]. The data points for ordinary chondrites (red circles) are generally plotted on this mixing line. This means that the isotope anomalies in ordinary chondrites are induced by the heterogeneous distribution of *s*-process nuclides in early Solar System. By contrast, the plot of enstatite (green circle) and Allende (blue circles) deviate from the mixing line towards the direction with lower $\mu^{142}Nd$ values. We consider that the offset from the mixing line is caused by the heterogeneous distribution of *p*-process nuclides in the early Solar System, because a part of ^{142}Nd was produced by the *p*-process and decay of a pure *p*-nuclide ^{146}Sm. With the correction for p-process contribution to $\mu^{142}Nd$, the mean μNd values of our multiple measurements for Allende are plotted on the terrestrial vs *s*-process mixing line (blue diamond).

Our results indicate that the negative $\mu^{142}Nd$ values observed in chondrites simply reflect the heterogeneous distribution of *s*-process nuclides for ordinary chondrites and *s*- plus *p*-process nuclides for carbonaceous chondrites. Although the Earth and parent bodies of chondrites do not share building blocks with a common Nd isotopic composition, the excess ^{142}Nd signature of the Earth would not necessarily require the existence of a hidden reservoir with a subchondritic Sm/Nd ratio deep in the Earth's mantle as proposed previously [5–6].

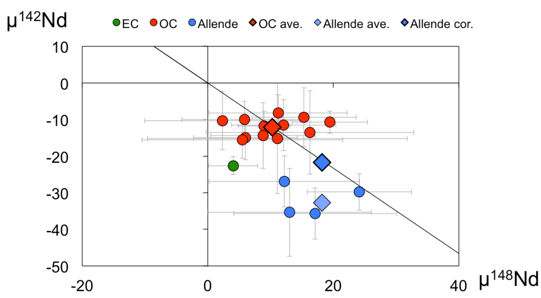

Fig. 1 *Plots of $\mu^{142}Nd$ and $\mu^{148}Nd$ values in chondrites.*

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